Structural Inspection of
Existing CSX Bridge at Kanawha River
Charleston, WV

Environmental Design Group
1329A Quarrier Street
Charleston, WV

January 5, 2004
Revised January 14, 2004

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1/14/04

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January 14, 2004

Mr. James Hemme, PE
Environmental Design Group
1329A Quarrier Street
Charleston, WV 25301

Subject: Preliminary Structural Inspection of the Existing CSX Bridge, Charleston, WV

Dear Mr. Hemme:

At your request, Ham Engineering, Inc., has preformed a preliminary visual inspection of the existing CSX Bridge crossing the Kanawha River in Charleston, WV. The existing bridge superstructure consists of a series of wood trestles, structural steel built-up girders, three minor structural steel trusses, and one major structural steel truss. The existing bridge substructure consists of wood bents on concrete foundations, steel bents on concrete foundations, steel bents on piling foundations, and full height concrete piers. It is not known if the concrete foundations are soil bearing or piling supported. Partial drawings for the structural steel girders and trusses were available for the purposes of the inspection; however, the available drawings consisted of a series of poorly made computer scans of the original drawings that left a considerable amount of original design information in question. No drawings were available for the wood trestles at the north and south approaches and the existing foundations. The original date of construction was noted as 1907 on the primary crossing drawings, with several additions and modifications that appeared to date as late as 1956.

We had planned to perform a structural analysis of the main span; however, due to a lack of member data for the main truss and more than expected original structural design data, we have not performed the structural analysis. Based on the design notes found on one of the drawings, the bridge was designed for a Cooper E-40 railroad loading which consists of two steam locomotives with their coal tender cars for a total weight of 568,000 pounds distributed over a total distance of 104 feet. Based on the above information, the linear live load due to the locomotives would be approximately 5460 pounds per foot of track. Also, the primary bridge trusses appear to have been designed for vehicular traffic on a former roadway structure that was cantilevered from the east side of the trusses. The framing for the roadway is shown on the 1907 drawings and remnants of the former structure can be observed in the field. The design live load for the roadway was 80 pounds per square foot over a 12-foot wide roadway for a uniform live load of approximately 960 pounds per foot. When combined with the train loading, the total live

load is 6420 pounds per foot. Since the proposed usage for the existing bridge is for a pedestrian live load of 100 pounds per square foot or approximately 1000 pounds per linear foot with an occasional maintenance vehicle, the original design live load would be approximately six times the proposed pedestrian loads.

The existing bridge was designed for a railway floor loading of 600 pounds per foot, a track weight of 500 pounds per foot, and a roadway weight of 600 pounds per foot for a total design dead load of 1700 pounds per foot. The proposed dead load for the concrete slab and the handrail system is estimated to be approximately 700 pounds per foot. Since most of the existing track weight of approximately 500 pounds per foot will be removed and replaced with approximately 700 pounds per foot of floor system, the net increase in dead load is approximately 200 pounds per foot. If a 2x8 pressure treated wood deck is used, the approximate dead load will be less than 100 pounds per foot, which is less than the weight of the existing track work to be removed. Note that the dead load and live load of the existing walkway was not included in the above discussions since it will remain and will be reused as a walkway in the future.

General Observations:

The following discussion represents potential structural defects and problems observed by Ham Engineering, Inc. personnel during our visual structural inspection in the period between December 19, 2003, and January 4, 2004. The report is based on visual observations made from either the ground or the existing bridge deck only. No ladders or scaffolds were used during this inspection to access the top or bottom of the existing trusses, girders, or trestles. No physical testing, radiographic testing, or material evaluations were done as a part of this inspection; therefore, all notations and recommendations are based on visual observations only.

At the south approach, the existing concrete cribbing retaining wall has failed in at least two locations between the mainline tracks and the wood trestle. It needs to be determined who owns, or will own, the property where the failures are located and how they will be fixed.

The paint on both the north and south approaches is in fair to poor condition on the main framing and the steel bents. The paint is nonexistent in many locations and peeling or flaking off in other locations with spots of an orange primer visible on the existing steel, indicating a possible lead based primer and/or paint system. The paint system on the primary trusses is in better condition; however, there are spots of orange primer visible on the trusses, indicating a possible lead based primer and/or paint system on the trusses also. EPA and West Virginia regulations related to disturbing and/or removal of lead based paint should be reviewed prior to renovating these painted areas.

At the south approach, extensive vegetation and poor site drainage are causing problems at the wood trestles and the steel bents. The structural steel base plates and anchor bolts of the steel bents are partially covered with vegetation and, in several locations, are below existing grade and exposed to standing water. The existing vegetation should be removed and the site graded to allow for drainage away from the existing structure and to

allow 6 to 12 inches of clearance between the final grade and the top of concrete piers.

Substructure Observations:

On the south approach, there are several locations where existing wood cross bracing has fallen and should be replaced in its original location with timbers similar to the original material.

In the north approach, there are cracks in the existing concrete piers that should be pressure grouted to seal the concrete from water penetration.

In the existing steel bents near Second Avenue, there were at least two anchor bolts that were observed to be completely rusted through, and in one case, missing. In the same steel bent, the bottom steel angles of the existing bent are almost completely rusted through. If both the anchor bolts and the bottom steel angles are ineffective, a structural stability problem may be created in the existing bent. Similar problems may be found in other bents, obscured now by soil, debris, and corrosion.

The foundations in the north approach between Kanawha Boulevard and Second Avenue appear to have been repaired in the past. The existing steel bents are no longer attached to concrete foundations; instead, they are attached to a system of steel grillage beams that are assumed to be supported by steel piling. The reason for this modification was not apparent; however, I suspect the foundations in this area may have settled excessively in the past.

Superstructure Observations:

Based on the visual inspection, we estimate that approximately 10 percent of the existing wood cross ties are in poor condition and should be replaced. Due to the design of the potential handrail construction, good or useable ties may be displaced and could be use to replace some of the poor ties.

Many of the existing wood cross ties in the MacCorkle Avenue crossing may be in poor condition since they were installed without lateral clearances to prevent material from falling off the train and through the bridge. This has allowed dirt and gravel to accumulate on the ties and has allowed vegetation to grow on the tracks. Ties in this area should be cleaned off and thoroughly inspected for rot and damage due to vegetation.

Both the north and south wood trestle and steel girder approach spans have a wood sidewalk and handrail cantilevered from the west side of the tracks. This sidewalk and handrail is in very poor condition and should be removed completely from the structure. At present, the existing sidewalk does not appear to be physically attached, just a wood stringer that extends parallel to the crossties and bears under the rails, preventing uplift of the sidewalk stringer.

The condition of the existing structural steel falls into two basic categories – the main river crossing and the approach spans. The condition of the four steel trusses that

used to replace some of the deteriorated cross ties. Most of the existing wood cross ties across MacCorkle Avenue and Kanawha Boulevard will have to be replaced.

Remove the existing wood walkway and handrail system on both the north and south approaches due to their poor condition. This walkway and handrail will be replaced with a new walkway system.

X-ray selected pin connected steel eyebars at the lower chord of all four steel truss spans to determine if there is any hidden corrosion or deterioration. Please note that this work should be done before the purchase of the bridge is finalized, due to the potential cost of eye bar repairs, if required.

Several steel bottom chord connection plates at the steel trusses show signs of deterioration and will need to be replaced long term.

Remove the existing wood walkways located inside of the trusses and upriver of the railroad tracks. The deck can be replaced in kind or in specific sections as determined later.

Install a new concrete deck and steel handrail system per the attached sketch. The handrail structure and infill should be designed to meet local building codes, specifically, the IBC 2000 Building Code. The construction should be either a vertical picket type or a chain link fence type. Over the existing roadways, the handrail system should extend high enough to prevent objects from being thrown from or dropped off the walkway. The exterior color can be either painted, galvanized, or powder coated.

<u>Conclusion:</u>

In summary, the structure of the existing bridge is in fair to good condition with several trouble spots as described above. If you decide to go forward with this project, I would recommend that the connection x-ray work be done before you commit to purchase the bridge, because the eye bar and pin connections could hide potential structural problems that would be very costly to repair.

If you have any questions or need additional information, please call at your convenience. Thank you.

Respectfully,

Judson C. Ham, Jr., PE

JUDSON C. HAM, JR. REGISTERED NO. 7699 STATE OF WEST VIRGINIA PROFESSIONAL ENGINEER

Elevation of Main Span crossing Kanawha River, looking downstream

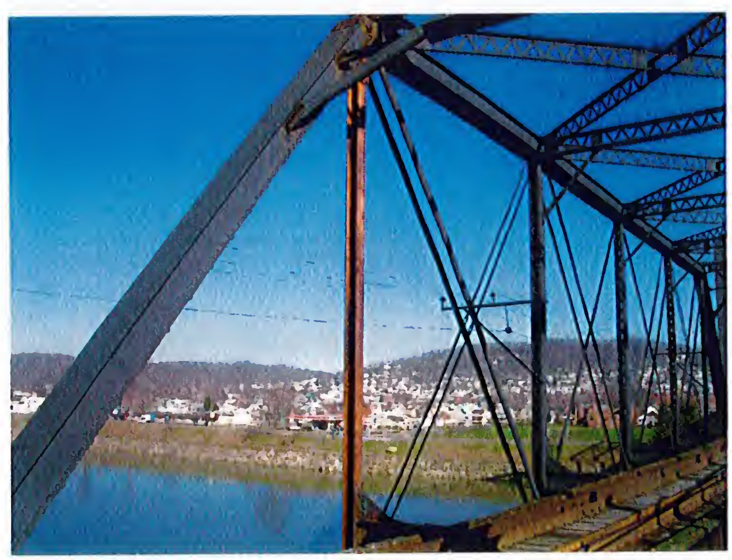
South Approach Trusses and concrete river piers, looking downstream

North Approach Truss

View thru South Truss showing track and walkway on the upstream side of the bridge. The existing wood deck and handrails will have to be replaced.

Failing handrail and walkway at the South Approach spans. The existing walkway and handrails should be removed.

Replaced Vertical Member at south end of second truss, an indication of possible damage or corrosion repair. Note the reddish orange color of the paint.



South End of South Approach Trestle

Heavy Vegetation in and around steel bents at South Approach

Deteriorated Base Platform Connection at South End

Bracing Blocking Kanawha Blvd. Sidewalk. This brace can be raised or relocated to provide adequate headroom for pedestrians.

Deteriorated bottom steel tie at Second Avenue Crossing. This steel member will have to be replaced.

Deteriorated Anchor Bolt near Second Avenue Crossing. Note that the lower half of the bolt is gone.

Ties are closely spaced to prevent material from falling through to MacCorkle Avenue has allowed vegetation growth causing possible tie damage. Note missing boards at the walkway to left.

End View of South Truss showing Framing for Pedestrian walkway, looking north.

Section View at Main Truss showing Tracks and Walkway, looking south.

Bottom Chord of Main Truss showing eight (8) Eye Bar Truss members. Selected number of joints should be X-rayed to verify member capacity

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Construction Cost Estimate, +/- 30%

Repair Failing Retaining Wall: ***

Remove and reinstall the existing concrete cribbing wall system in two locations and add new granular backfill.

Estimated Cost = $5000 *

Regrade South Trestle Area: ***

Clear and grubb the existing vegetation from the south approach of the bridge from the south abutment to approximately MacCorkle Avenue. Regrade the entire area so that the top of concrete at all foundations is at least 6 inches above the surrounding grade. Provide new drainage piping as required to accommodate revised site grading. Power wash all of the structural steel base plates and the top of existing concrete foundations.

Estimated Cost = $10,000 *

Repair Base of Existing Steel Bents: ***

Remove damaged and deteriorated steel sections at the base plates, the lower sections of the steel bents, and the bracing, and replace with steel of a similar size and section. Work is assumed to include abatement of lead based paint on the lower 10 feet of the steel bents.

Estimated Cost = $100,000 *

Replace Fallen or Missing Wood Braces: ***

Reinstall or replace fallen and missing wood bracing at the existing trestles with wood of similar sections.

Estimated Cost = $5000 *

Pressure Grout Foundation Cracks: ***

Pressure grout cracks with epoxy adhesive in the existing concrete foundations.

Estimated Cost = $5000 *

Construction Cost Estimate, +/- 30 %

Replace Deteriorated Wood Cross Ties:

Remove and replace approximately 5 percent of the damaged and deteriorated treated wood crossties with treated wood crossties of a similar size. Some good existing wood crossties may be displaced by the handrail installation and available for replacement.

Estimated Cost = $ 13,000 *

Remove Existing Wood Walkway:

Remove the existing wood sidewalk and handrail system from both the north and south approach spans. The existing walks will not be replaced. It is assumed that most of the demolition work will be done by crane from grade.

Estimated Cost = $10,000 *

X-ray Existing Eye Bar Connections:

X-ray selective eye bar joints at the lower chord panel points of all four trusses. **This work should be done prior to finalizing bridge purchase.**

Estimated Cost = $10,000 *

Furnish and Install Beam and Handrail System:

Provide the structural steel materials required for the proposed handrails, the beam supports, and the continuous edge angles. The structural steel is proposed to have an epoxy paint system including a commercial blast cleaning, an inorganic zinc primer, and a high build epoxy enamel finish.

Estimated Cost = $465,000 **

Labor to erect the structural steel beams and the handrail systems. Assumes the existing rails can be left in place and then removed in short sections later.

Estimated Cost = $460,000 **

Material and labor to install the proposed vinyl coated chain link fencing on the handrails.

Estimated Cost = $125,000 **

Construction Cost Estimate, +/- 30 %

Furnish and Install Concrete Floor Deck:

Provide galvanized concrete form deck and reinforcing required for the proposed 10 feet wide by 5-inch thick concrete deck.

Estimated Cost = $55,000 **

Labor to install the edge angles, the metal form deck, and the reinforcing steel. Labor to pour, place and finish the concrete slab using 4000 psi, air entrained concrete. Broom finished surface with tool or saw cut joints. Assume job site access for a crane along the bridge.

Estimated Cost = $594,000 **

Total Estimated Cost = $1,857,000

Notes:

* = Estimated Pricing

** = Pricing Based on Vendor Discussions

*** = Possible Short Term Cost Deferment

Alternate Floor Construction:

Instead of using a cast in place concrete floor, a treated 2x8 wood plank floor could be used. The treated wood floor would span across the existing wood cross ties, leaving the two exterior 4" by 8" wood curbs in place and allowing a walkway width of approximately 8'-8" wide. The new steel handrail posts would be bolted to the exterior wood curbs. This would eliminate the W6 cross beams, the two continuous L 5x 3 ½ curb angles, the galvanized metal form deck, the steel reinforcing, and the concrete placement and finishing. The steel and concrete savings would be approximately $800,000; however, the price would be increased by approximately $200,000 to purchase locally and install approximately 37,300 square feet of treated 2x8 wood flooring with related galvanized ring shank nails. The net price difference would be a reduction of approximately $600,000.

Total Estimated Cost = $1,257,000

January 14, 2004

Ham Engineering
South Charleston, WV

PROJ. NO.: ______ SHEET ____ OF ____

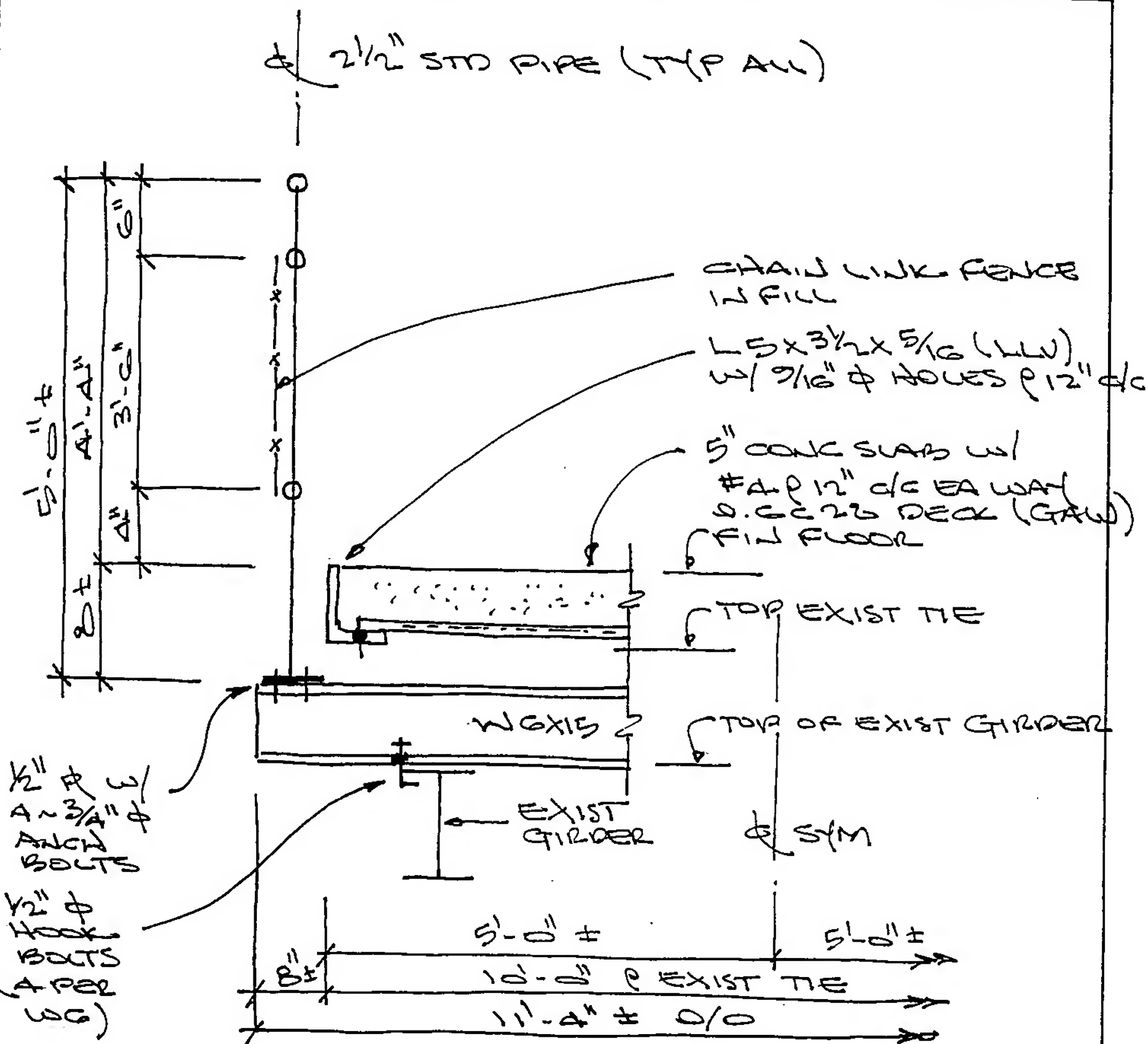
PROJ. NAME: ______

CLIENT: ______

DESIGNED BY: JCH DATE: 1/04

SUBJECT: PRELIMINARY HR

CHECKED BY: ______ DATE: ______



TYPICAL HANDRAIL SUPPORT
AT 8' ± CENTER TO CENTER

COLOR TO MATCH EXIST BRIDGE ∴ DK BROWN.
TOTAL LENGTH BRIDGE = 4300 FT ± ∴ 8600 LF HR
ASSUME 1000 FT ± CURVED @ 8 DEGREES ∴ 2000 LF
SHOP WELD, FIELD BOLT CONN AND SPLICE.

Ham Engineering
South Charleston, WV

PROJ. NO.: 03149 SHEET ____ OF ____

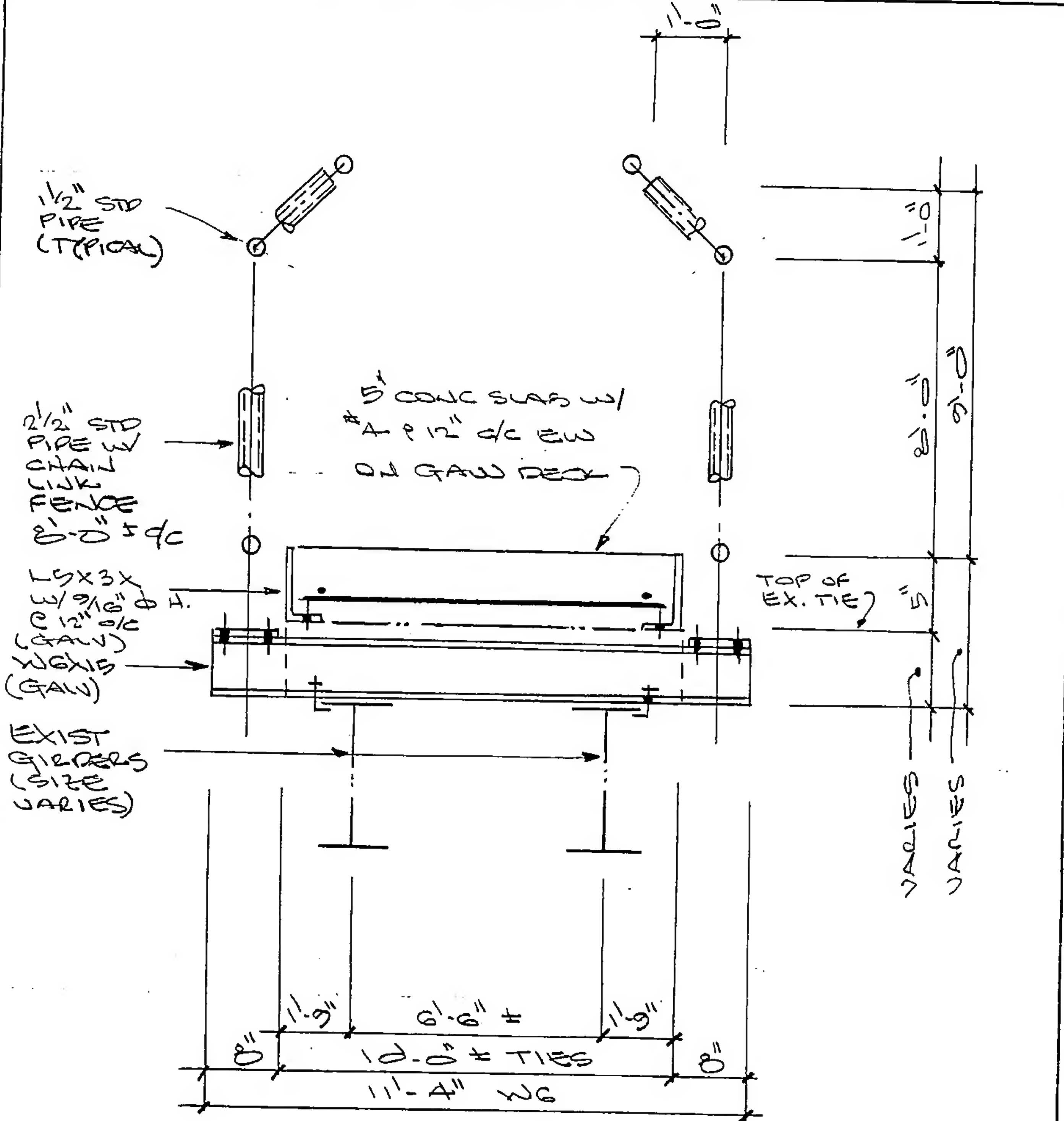
PROJ. NAME: CSX BRIDGE

CLIENT: EDG

DESIGNED BY: DCH DATE: 1/04

CHECKED BY: ____ DATE: ____

SUBJECT: SECT @ WALKWAY



SECTION @ WALKWAY (OVER STREETS)

NTS.

Ham Engineering

PROJ. NO.: ______ SHEET ____ OF ____

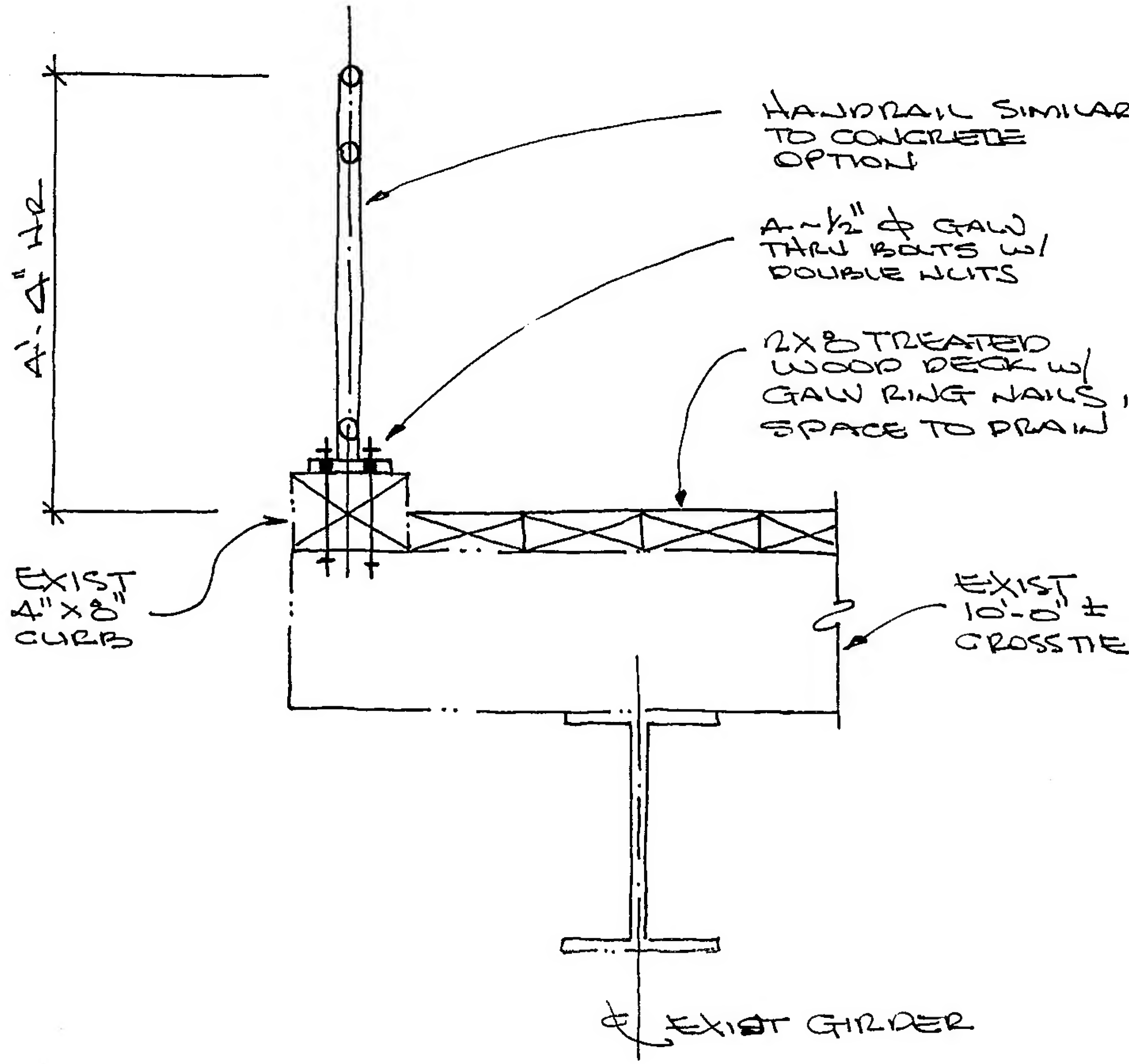
PROJ. NAME: CSX BRIDGE

CLIENT: EPG

DESIGNED BY: JCH DATE: 1/04

SUBJECT: ALT WOOD DECK

CHECKED BY: ______ DATE: ______



ALTERNATE WOOD FLOOR DETAIL

NTS

Ham Engineering

PROJ. NO.: ______ SHEET ____ OF ____

PROJ. NAME: ______

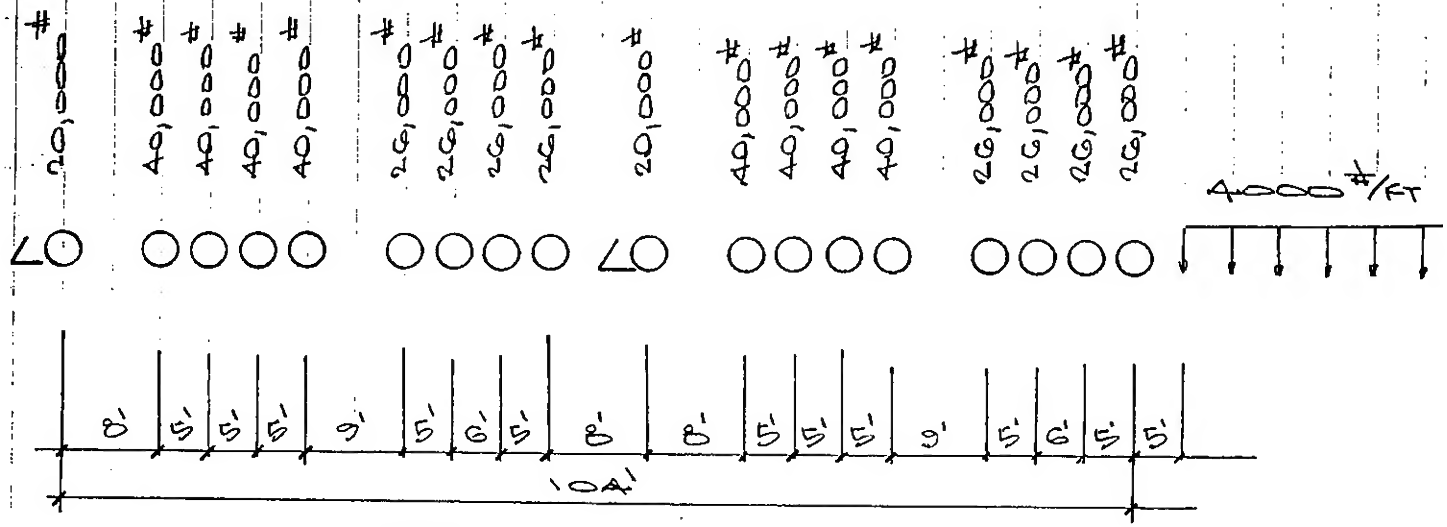
CLIENT: ______

DESIGNED BY: ______ DATE: ______

CHECKED BY: ______ DATE: ______

SUBJECT: ______

COOPER E-40 LOADING



LOAD ELEVATION

TOTAL WEIGHT = 568,000 POUNDS

APPROX LINE LOAD = $\frac{568{,}000\#}{104\ ft}$ = 5462 POUNDS/FOOT

CHAPTER XI

DESIGN OF SIMPLE RAILROAD BRIDGES

120. Types.—Simple railroad bridges can be divided into four general types: beam bridges, plate girders, viaducts, and truss bridges. Plate girders and truss bridges can be further divided into deck and through bridges; deck when the track is supported on the top of the structure; and through when the track is between the main girders or trusses. Beam bridges and viaducts are always deck bridges.

121. The Specifications prepared by the American Railway Engineering Association, referred to in the preceding chapter, will be used throughout this work.

122. The Live Load usually specified for railroad bridges consists of two typical consolidated locomotives and tenders coupled in tandem followed by a uniform train load, and a special load concentrated on two axles which is used in case of very short spans. The most common loading of this type is that known as "Cooper's Loading," devised by Theodore Cooper, M. A. Soc. C. E. Cooper's loadings vary in weight and are designated, beginning with the lightest, as $E30$, $E35$, $E40$, $E45$, $E50$, $E55$, and $E60$. These loadings vary by a certain ratio so that if any stress, shear, bending moment, etc., due to any one of the loadings be known the intensities of the same due to any one other of the loadings can be obtained by direct proportion, and hence any tables or diagrams giving the shears, moments, etc., for any one of the loadings can be used for any of the other loadings. The figures following the letter E are the indices of the ratio referred to above. Thus, for example, if any stress, shear, etc., due to $E40$ be known, the intensity of the same for $E50$ will be 50/40 of that due to $E40$; 60/40 for $E60$; 35/40 for $E35$; and so on. Most of the railroads in this country have adopted some one of Cooper's loadings, either exactly or slightly modified. The trend has been toward the using

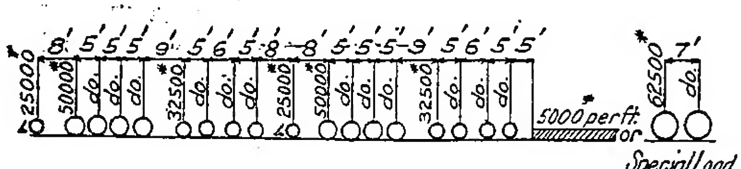


Fig. 151

of the heavier loadings. At present $E50$, represented in Fig. 151, is used quite extensively. The spacing of the wheels is the same for all of the loadings.

The $E40$ loading is the most convenient to use owing to the loads being in even thousands of pounds.

Table A* gives for this loading moments about any wheel of the wheels to the right or to the left of it, as will be seen upon inspection.

* The student should verify the results given in this table.

CHAPTER I

PRELIMINARY

1. Structural Engineering.—The part of Civil Engineering pertaining to the designing of steel structures, such as bridges, buildings, towers, etc., is known as Structural Engineering. The work involved consists, principally, in determining the stresses, selecting the material to be used, known as sections, and the contriving and drawing of the details. But, in addition to this work, the structural engineer has, as a rule, the designing of a great deal of incidental construction, such as foundations, concrete floors, roofs, etc.

In order to design structures properly, one must be perfectly familiar with the material used in their construction and have a clear understanding of the manner in which their manufacture and erection are accomplished as well as have a thorough knowledge of the mechanical principles involved throughout. A properly designed structure is one wherein no mechanical principles are seriously violated and which at the same time is economic in material and easily manufactured and erected.

2. Structural Material.—Steel, concrete, stone, and wood are the principal materials used by the structural engineer in the construction of modern structures. However, cast iron, wrought iron, and a few other materials are used in a few cases, as will be designated when these cases present themselves in the text. Concrete and stone will not be treated in this book further than to designate certain allowable pressures.

3. Manufacture of Steel.—In describing in a general way the usual process of making steel, we can say that steel is made from iron ore which is mined and carried to a blast furnace through which it is run together with coke and limestone and thus converted into cast iron. The cast iron is then taken to either an open-hearth furnace or to a Bessemer furnace, usually spoken of as a Bessemer converter, and there converted into steel. When the conversion is complete, the molten steel is run into ingot molds, which are rectangular cast-iron molds, and molded into ingots. These ingots are allowed to cool to some extent. Then the molds are pulled off and the ingots are taken to a rolling mill, which is known as a slab or blooming mill, where they are heated in what is known as a soaking pit until they have the proper temperature for rolling. Then they are rolled to a convenient rectangular cross-section and cut up into convenient-sized pieces known as slabs or billets. These billets or slabs, as the case may be, are then taken to another rolling mill and reheated very much the same as the ingots just described, and then rolled into structural shapes, plates, rails, etc., ready for the market.

Sometimes the cast iron from the blast furnace is cast into rough bars, known as pig iron, which may be stored and converted into steel or molded into castings at any desired time, or it may be shipped to some distant point to be utilized in the same manner. At the most modern plants the molten metal is taken directly from the blast furnace and converted into steel without letting it cool to any great extent.

The steel produced in an open-hearth furnace is known as "open-hearth steel," while the steel produced in a Bessemer converter is known as "Bessemer steel." Open-hearth steel is considered more reliable in every respect than Bessemer, and, consequently, the Bessemer steel is being fast replaced by the open-hearth product. In fact, most engineers at present exclude the use of Bessemer steel in structural work altogether.

4. **Grades of Common Structural Steel.**—There are three recognized grades of common structural steel: Medium Steel; Soft Steel; Rivet Steel.

Medium Steel is a medium-hard steel which has practically replaced all other grades of steel in structural work. It has an ultimate strength of 60,000 to 70,000 pounds per square inch, and an elastic limit of 30,000 to 35,000 pounds per square inch.

Soft Steel is softer than medium steel. It was the grade of steel first used in structural work, but has been practically replaced by medium steel. It has an ultimate strength of 52,000 to 62,000 pounds per square inch and an elastic limit of 26,000 to 31,000 pounds per square inch.

Rivet Steel is a very soft steel used almost exclusively for making rivets and bolts. It has about the same chemical composition as wrought iron, but has a higher ultimate strength and elastic limit. It has an ultimate strength of 48,000 to 58,000 pounds per square inch and an elastic limit of 24,000 to 29,000 pounds per square inch.

5. **Nickel Steel** is a steel containing from 2 per cent to $3\frac{1}{2}$ per cent of nickel. It has an ultimate strength of 80,000 to 112,000 pounds per square inch and has a very high elastic limit—something like 60,000 pounds per square inch. This metal has been used recently in some of the large bridges in this country.

6. **High Carbon Steel** is a hard steel which contains more combined carbon than the ordinary medium steel. It has practically as high ultimate strength and elastic limit as nickel steel. It is used almost exclusively in the form of rods to reinforce concrete.

7. **Wood,** or timber, as it is usually spoken of, is used in structural work principally for floor and roof covering. The timber mostly used is white oak and yellow pine, both of which have an average ultimate crushing strength of about 7,000 pounds per square inch, and an ultimate tensile strength of about twice that amount.

8. **A Casting** is made by running molten metal into an impression made in sand by means of a wooden pattern which is shaped to the size of the metal piece desired. The castings used in structural work are made of either cast iron or steel. The castings made of steel are much stronger than those made of cast iron but cost more. The steel used for making castings has a somewhat different chemical composition than that of rolled steel, referred to above. It is produced in the same way, however, the chemical composition being controlled mostly in the mixing of the charge.

9. **Structural Steel Shapes.**—The I-beam, channel, angle, Z-bar, and T-shape, shown in Fig. 1, are the principal steel shapes used in structural work. The T-shape is not used very extensively except for very special work. Plates, while they are not classified as structural shapes, are really used in a more general way than the shapes.